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ABSTRACT

Presented are some characteristics of curricula in engineering which existed in various educational institutions in the United States and which lead to the award of associate degrees. A tentative classification system by which content areas can be identified is offered, along with an analysis of curricula as they existed in different institutional settings, and identified needs for further study and analysis. (Author/RE)

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American Society for Engineering Education

ASSOCIATE DEGREE CURRICULA IN ENGINEERING TECHNOLOGY: SOME CHARACTERISTICS

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Engineering Technology Education Study

ETE Study Report No. 6
May, 1970

ASSOCIATE DEGREE CURRICULA IN ENGINEERING TECHNOLOGY: SOME CHARACTERISTICS

Introduction

This paper describes briefly some characteristics of curricula in engineering technology which exist in various educational institutions in the United States and which lead to the award of associate degrees. It provides a tentative classification system by which content areas can be identified, presents an analysis of various curricula, compares curricula as they exist in different kinds of institutional settings, and identifies needs for further study and analysis. The paper was prepared as background information for the Advisory Committee to a national study of the role and scope of engineering technology education being conducted by the American Society for Engineering Education with support from the National Science Foundation.

Population

Kinds of Institutions

Institutions which offer educational programs leading usually to the award of associate degrees in engineering technology are of various types. A seven-fold classification system is useful. Kinds of institutions may be identified as follows:

1. Single purpose institutions having engineering technology education as their sole institutional objective; the term *monotechnical institutes* will be adopted in this paper to describe such schools.

2. Institutions with a variety of objectives related to technical and occupational fields, including programs related to business, health, and public service as well as to engineering; the term *polytechnical institutes* will be used here to designate these institutions.

3. Community and/or junior colleges which include an occupational-technical program as well as a liberal arts, "university parallel," "transfer" program; such colleges will be referred to as *comprehensive community colleges*.

4. Universities or other senior institutions which include associate degree programs in engineering technology as part of their offerings, either on the main campus or at a branch campus; these, regardless of the actual name of the institution, will be called *universities*.

5. Special educational units set up with a company organization to provide educational experiences for inservice or preservice employees; the term *company schools* will be used in reference to this kind of unit.

6. Army, navy, air force, or other military service schools devoted to engineering technology education; such units will be called *service schools*.

7. Institutions which provide home study materials so that individuals can complete a program of study by correspondence; these will be called *correspondence schools*.

A substantial majority of the activity in engineering technology education occurs in monotechnical institutes, polytechnical institutes, comprehensive community colleges and universities. While the importance of company schools, service schools and correspondence schools and the value of their contributions cannot be denied, it is within institutions of the first four types that engineering technology education mainly occurs.

Size of Population

It is extremely difficult to establish an accurate inventory of the curricula with which this paper is concerned. The literature and the various published directories give widely differing estimates of the size of the population. Several factors may account for discrepancies which have been found:

1. The term "engineering technology" is not uniformly defined.

2. The term "associate degree," while adequately defined, is often used in a context such as "...associate degrees or equivalent awards...", a practice which tends to contaminate statistics based on the degree.

3. Changes in the structure of institutions, the founding of new institutions, and name changes of older institutions result in both duplications and omissions from directory lists.

4. Time lags between the collection of data and its publication create discrepancies.

5. Institutions often report as "curricula offered" all programs appearing in the published catalog, regardless of whether the curricula actually have enrollments.

6. Multicampus institutions, especially, report data in differing ways; for example, some institutions report separately the curricula which are replicated at different campuses or branches while other institutions report one curriculum only.

Published directories are useful only in making tentative estimates. For example, one recent publication[1] lists over 5000 curricula offered by some 830 institutions, but not all the curricula listed lead to associate degrees. Another directory[2] contains over 1200 institutional names but includes among its listings some secondary schools as well as higher institutions. Neither reference is entirely reliable and each overestimates the population.

The standard source of directory information for institutions of higher education, the U.S. Office of Education's *Educational Directory, Part 3*, is of little assistance, for it does not identify in sufficient detail the kinds of curricula offered.[3]

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[1] *Career Opportunities; Engineering Technicians*, J.G. Ferguson Publishing Company, Chicago, Ill.: 1969. (One volume in the series *Career Opportunities for Technicians and Specialists;* Walter M. Arnold, Series Editor; Walter J. Brooking, Volume Editor.)

[2] *Technician Education Yearbook, 1969-70*, Prakken Publications, Inc., Ann Arbor, Michigan: 1969.

[3] See, for example, *Educational Directory, Part 3/1968-69*, U.S. Government Printing Office, Washington: 1968.

Two recent publications, however, are useful. In 1969, the Engineering Manpower Commission conducted a survey of degrees awarded in technology. The report of this survey[1] stated that 394 institutions had made associate degree awards during the 1968-69 year. There is some evidence that this is a low estimate, for a number of the institutions which had in 1968 responded to a similar EMC survey did not report in 1969.[2] The EMC data also suffer from confusion in reports from multicampus institutions. The National Center for Educational Statistics of the U.S. Office of Education furnishes one additional clue to the size of the population. A publication issued in 1969 and based on the 1967-68 academic year suggests that approximately 450 institutiona made "formal awards" to students completing programs "at the technician or semiprofessional level."[3] The NCES data, again, is believed to underestimate the population, since many of the institutions which did report to EMC in 1969 had not reported to NCES in 1968.

The union of the set of institutions reporting to EMC with the set reporting to NCES is believed to produce a list of acceptable accuracy. Such a union contains 563 institutions. A similar operation to estimate the number of curricula offered yields a value of 1595; this figure, however, is probably less valid than the previous one, since some differences existed in curriculum classification practices by EMC and NCES.

Nature of Population

Table 1 contains in summary form some observations about the characteristics of about 560 institutions which offer nearly 1600 different associate degree curricula in engineering technology.

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[1]John D. Alden, "Technology Degrees, 1968-69," *Engineering Education*, January, 1970, pp. 410-415.

[2]*Ibid*, p. 410.

[3]National Center for Educational Statistics, *Associate Degrees and other Formal Awards below the Baccalaureate, 1967-68*, U.S. Government Printing Office, Washington: 1969. See especially Table 7, pp 43-62.

TABLE 1.--General Characteristics of Institutions which offer Engineering Technology Curricula

Item	Comments
Control	86% public, 14% private
Type	87% are two-year institutions 13% are universities or four-year colleges which include associate degree curricula in their offerings
Emphasis	10% offer engineering technology only 13% offer a variety of technical programs but deal only in technical education 64% are comprehensive community colleges 13% are senior colleges or universities
Accreditation	11% have at least one curriculum accredited by the Engineers' Council for Professional Development 92% are accredited by the appropriate regional accrediting association
Extent of Offerings	80% offer four or fewer curricula 20% offer more than four curricula
Popularity of Offerings	Electrical/Electronics Technology is offered most frequently (30% of the total curricula, 50% of the institutions, and 25% of the awards) Mechanical Technology is second in frequency of offering (12% of the total curricula, 25% of the institutions, and 13% of the awards)

Curriculum Characteristics

Conceptual Framework

Engineering technology curricula, although they may differ from one another in certain respects, are expected to have many

characteristics in common. An analysis of existing curricula should reveal some major patterns of commonality and should suggest ways in which curricula can be distinguished. The patterns of contemporary practice, in turn, might suggest goals for future evolution of such curricula.

Based on such a conceptual framework, a curriculum analysis was undertaken. Preliminary investigation had suggested that three variables would be of major usefulness in such an analysis of engineering technology curricula:

1. Institutional setting
2. Curriculum Structure
3. Cognitive domain of curriculum

For analysis purposes a curriculum's "institutional setting" was defined as the *kind* of institution--monotechnical institute, polytechnical institute, comprehensive community college, etc.--in which the curriculum was found; the "curriculum structure" was a profile of the required credit hours in various curricular areas; and the "cognitive domain" was the major emphasis of the curriculum, that is, the technical discipline (drafting, electronics, highway construction, etc.) on which it concentrated.

Two additional variables, "accreditation by the Engineers' Council for Professional Development" and "topic coverage in selected areas" were initially expected to be somewhat useful in discrimination of curricula. The "accreditation" variable is treated here; the "topic coverage" variable has been reserved for a separate report.

A number of other possible variables existed but were rejected because it was believed they possessed limited relevance. Such variables included control (private vs. public), age of curriculum, enrollment in curriculum, age of institution, credit basis (semister, quarter, other), location of institution (urban, rural), and others.

Procedure

A sample of 120 engineering technology curricula were chosen

and subjected to analysis. This was essentially an *arbitrary* sample. It does not have--nor was it intended to have--the statistical properties of randomness, stratification, or representativeness. Rather, the curricula selected were ones judged likely to have influence--past or future--on the trends in engineering technology education. A brief description of the sample appears as Appendix A, along with some justifications for its appropriateness.

The results of the analysis are given in a later section of the paper.

Definitions

For the purposes of this paper, the following definitions related to curriculum content are adopted:

Technical specialty--technological subject matter content in an engineering technology curriculum in which a student concentrates study; the "major" of a curriculum. For example, technical specialty subject matter in an electrical technology program usually will include college courses entitled "electrical machinery," "transmission networks," "microwaves," and the like.

Related technical studies--technological subject matter content in an engineering technology curriculum related to some area of technology or to the development of skills to support a technology, but which is not directly related to the specialty of the curriculum. For example, related technical studies in an electrical technology curriculum might include college courses entitled "engineering drawing," "manufacturing processes," "industrial materials," or the like.

Applied sciences--subject matter content in an engineering technology curriculum involving basic mathematical and/or scientific principles applied to technical problems and situations. Derived from the "pure sciences", the technical sciences may include such areas as statics, dynamics, strength of materials, fluid mechanics, thermodynamics, statistics, electric theory, and properties of matter. The "applied sciences" of an engineering technology curriculum are analogous to the "engineering sciences" of an engineering curriculum.

Physical sciences--chemistry, physics and integrated courses in chemistry and physics.

Mathematics--subject matter content beyond the level of "intermediate algebra", that is "college algebra" and other mathematics subjects including trigonometry and calculus which have college algebra as a co- or pre-requisite.

Communications--subject matter content related to grammar, rhetoric speech, technical writing and other phases of language except literature and requiring four high school units in English as a pre-requisite.

Humanities/Social studies--subject matter content related to literature, the arts, philosophy, psychology, history, sociology, political sciences, and the like.

Other studies--subject matter content in a curriculum not classifiable under one of the preceding categories; these include R.O.T.C., physical education, life science, foreign language, and "free electives" not identifiable by category.

A "Typical" Engineering Technology Curriculum

The sample of 120 engineering technology curricula examined displayed patterns of similarity, although some variance was detected. Table 2 summarizes the major curriculum characteristics of these programs in terms of semester hour credits required in various curricular areas. The range, the mean (adjusted to the nearest half-credit), and the mode of the required credits are reported. Appendix B contains a discussion of the techniques used in arriving at these results.

As can be noted from Table 2, the requirements in each curricular area had considerable apparent variation. Part of this variation is real and is to be expected, due to the differences in program objectives at different institutions. On the other hand, some of the variation is artificial and was introduced by the classification scheme used in this study. For example, the introductory courses in Chemistry which appeared in the Chemical Technology programs analyzed were classified as "physical sciences" rather than "technical specialties"; these classification procedures *per se* contributed to the low extreme in the range of requirements in the "technical specialty" area and the high extreme in the "physical sciences" category.

TABLE 2.--Curriculum Characteristics of Associate Degree Programs in Engineering Technology

Curricular Area	Semester Credits Required		
	Range	Mean[a]	Mode
Technical Specialty	8-42	23	24
Related Technical Studies	0-22	8	8
Applied Sciences	0-22	7	8[c]
Physical Sciences	4-18	7	8
Mathematics	4-14	8.5	10[d]
Communications	3-12	6	6
Humanities/Social Studies	0-15	7	6
Other	0-14	2	2
Total Technical Studies[b]	24-51	39	40
Total Curriculum	60-83	71	72

[a]Adjusted to nearest half semester credit; for computed Values, see Table 3.

[b]Includes technical specialty, related technical studies and applied sciences.

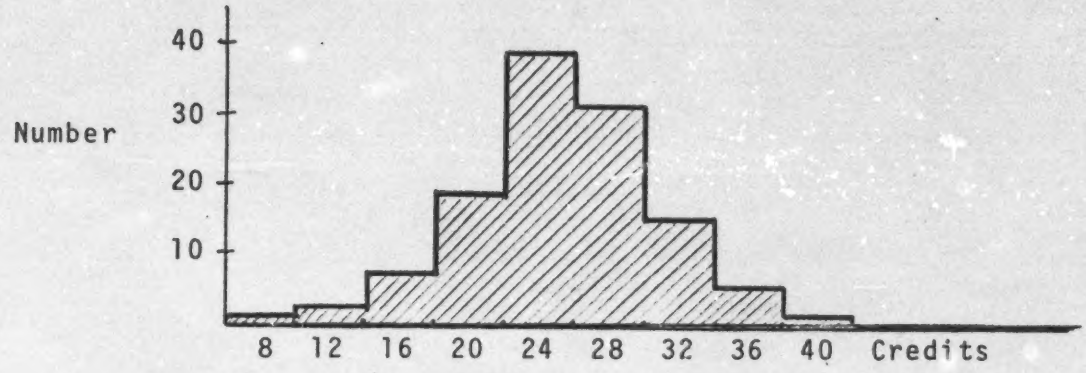
[c]High frequencies at 0 and at 4 semester credits were also noted.

[d]High frequency at 6 semester credits was also noted.

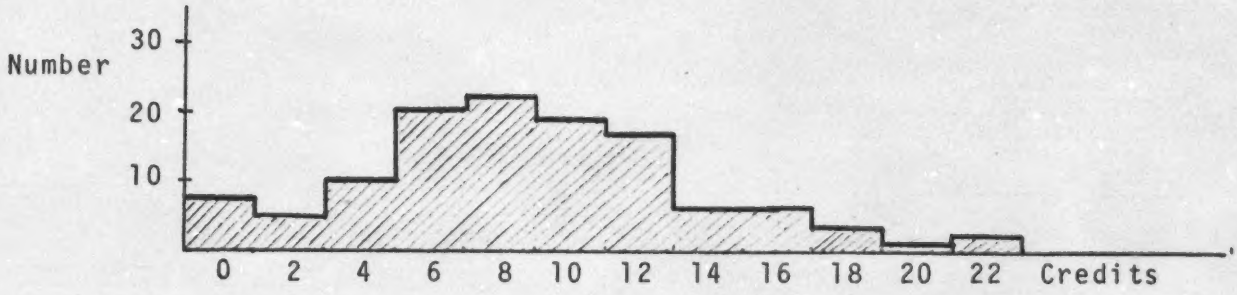
The histograms of Figure 1 give some insights into the variations and central tendencies which were found.

Table 3 summarizes some relevant statistical properties of the data used. In Table 3, a "computed mean" is the result of a numerical calculation, to the nearest tenth of a semester credit, of the mean of the data being analysed; this is a stable statistic which is useful for making comparisons within the data base, but is not especially meaningful descriptively. The 'adjusted mean", a value rounded to the nearest half-credit, is more useful as a nominal value. The standard deviation has the usual meaning of that statistic. "Relative variability" as reported in the table is a statistic which gives an indication of the extent to which data are clustered about their mean; it

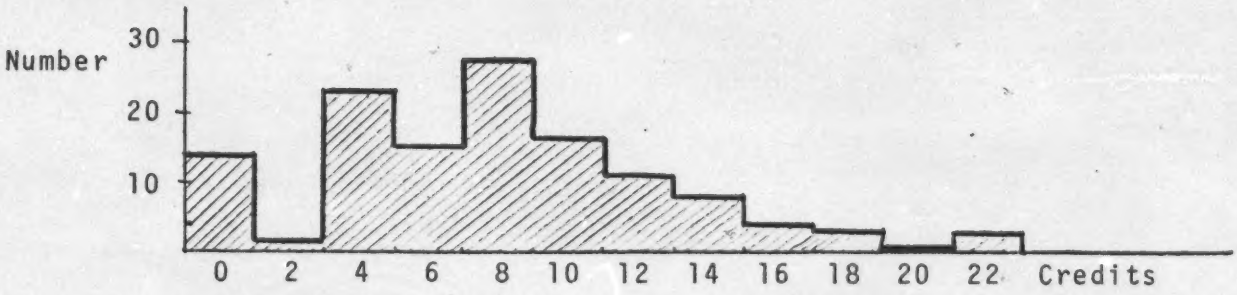
FIGURE 1.--Distribution of Semester Credit Requirements by Curricular Area in 120 Engineering Technology Curricula



(a) Technical Specialty

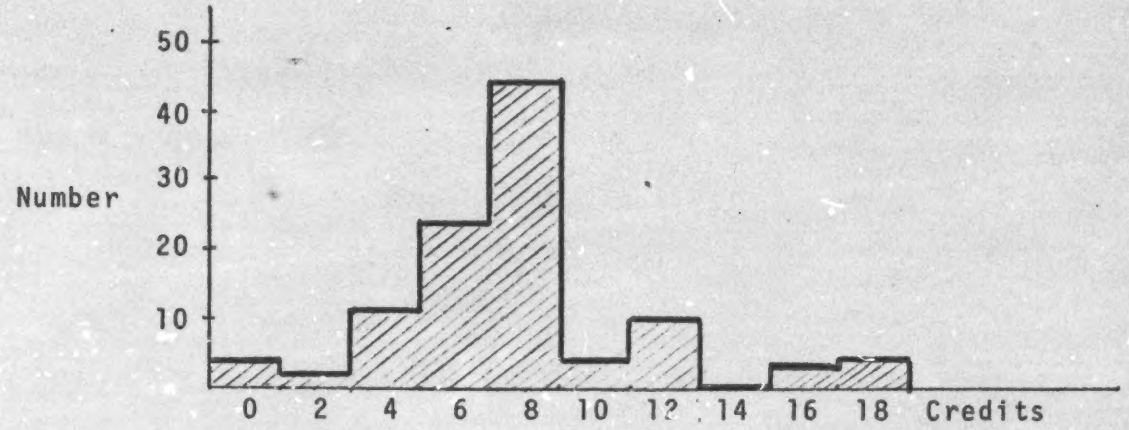


(b) Related Technical Studies

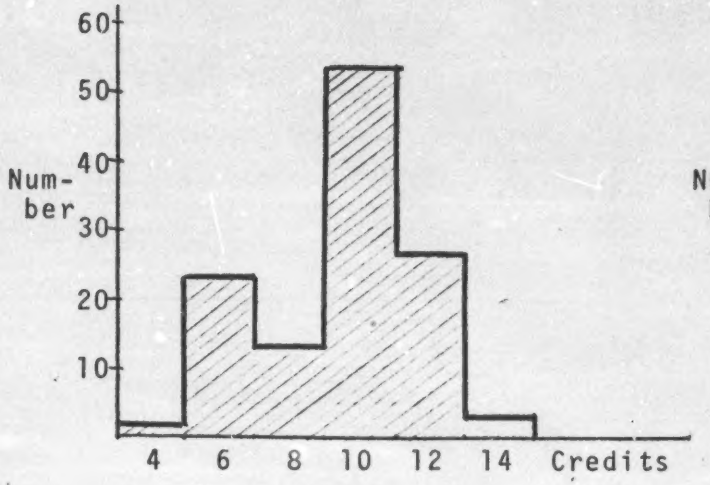


(c) Applied Sciences

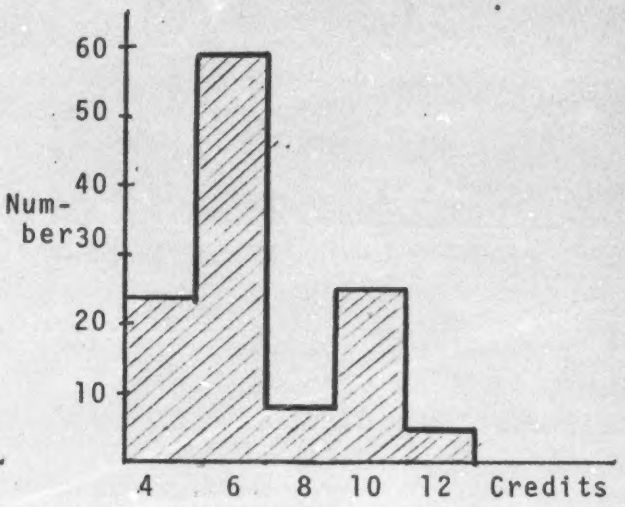
FIGURE 1 (Continued)



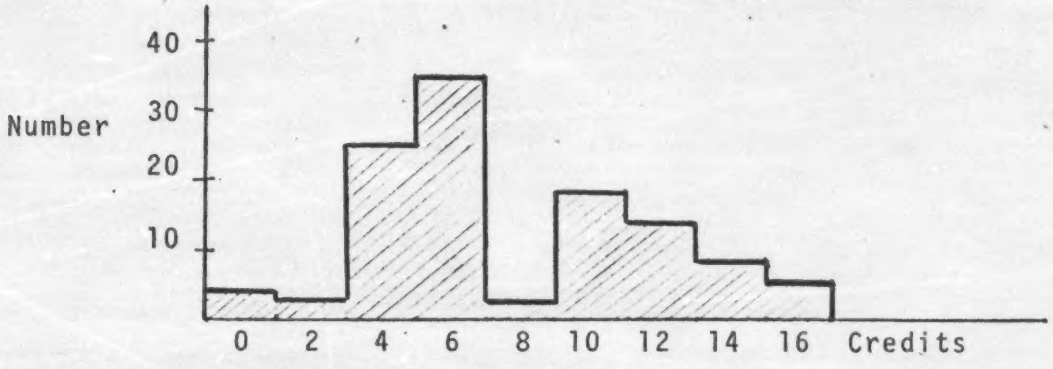
(d) Physical Sciences



(e) Mathematics

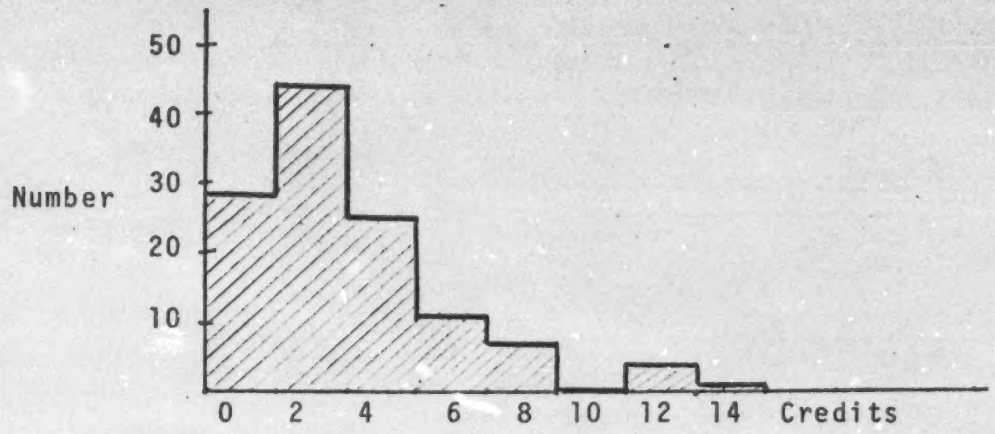


(f) Communications

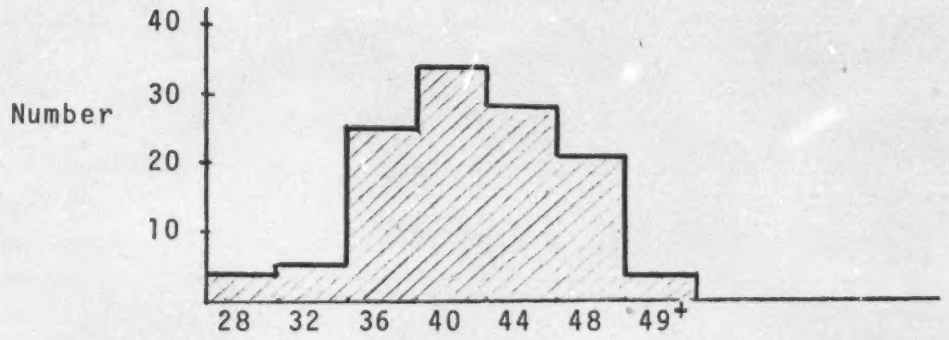


(g) Humanities/Social Studies

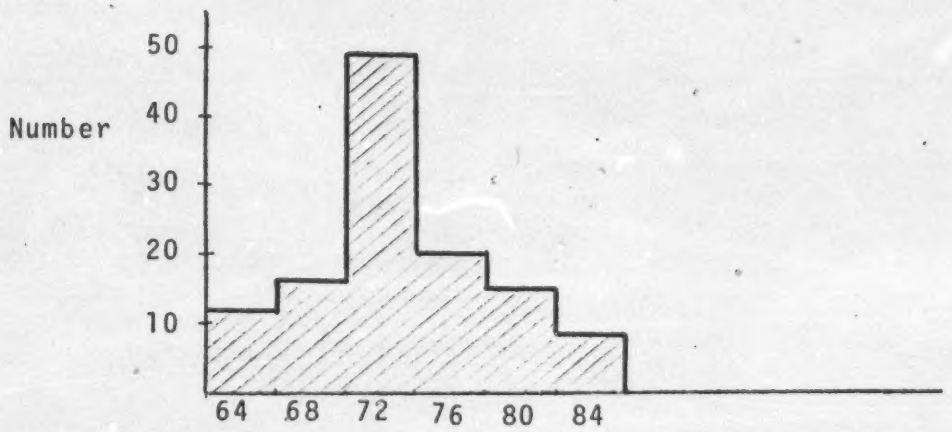
Figure 1 (Continued)



(h) Other



(i) Total Technical Studies



(j) Curriculum Total

TABLE 3.--Statistical Characteristics of Data Used in Development of a "Typical" Engineering Technology Curriculum

	Computed Mean[a]	Adjusted Mean[a]	Standard Deviation[a]	Relative Variability[b]	Conformal Limits[a]
Technical Specialties	23.2	23	5.52	23.8	1.8
Related Tech. Studies	7.8	8	4.62	59.2	1.5
Applied Sciences	6.7	7	4.70	70.0	1.5
Physical Sciences	6.9	7	3.08	44.7	1.0
Mathematics	8.5	8.5	2.20	25.8	.7
Communications	5.9	6	2.24	38.0	.7
Humanities/ Social Studies	6.7	7	4.00	60.0	1.3
Other	2.1	2	3.94	185.7	1.3
Total Technical Studies	39.1	39	5.44	14.0	1.8
Curriculum Total	71.1	71	6.68	9.4	2.3

[a]In semester credits

[b]In percent

is a rough measure of kurtosis. In this situation, a relative variability less than 25 percent implies a significantly leptokurtic distribution (one more peaked than the "normal" distribution) having the mean value itself occur frequently in the data. A relative variability near 50 percent is associated with data having a multimodal distribution (as in the case of "Communications," where a distinct bimodal pattern is observed). A relative variability exceeding 100 percent (as in "Other", Table 3) is associated with data having an extremly platykurtic

distribution or lacking any appreciable central tendency at all. For data with relative variability exceeding about 35 percent, the strongest mode is probably a better representation of practice than is the mean.

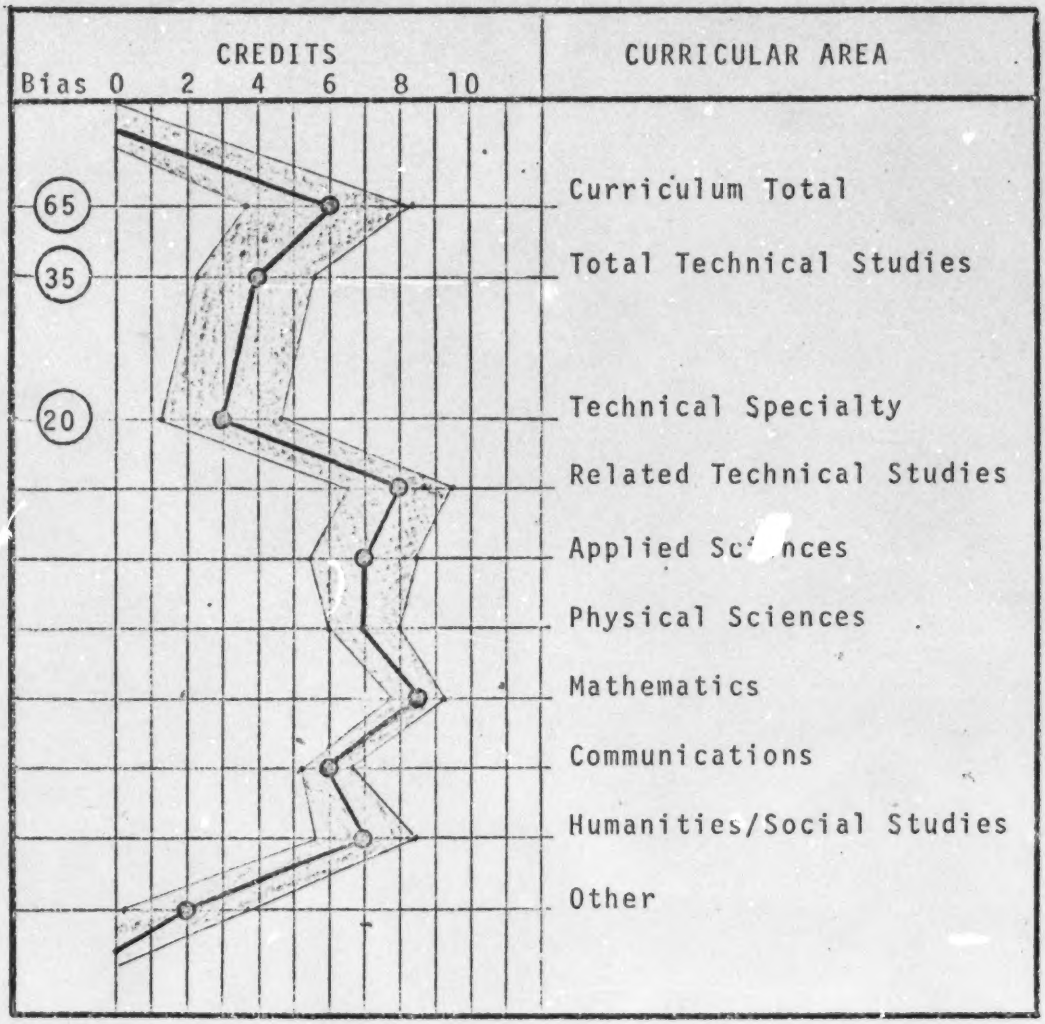
The "conformal limits" reported in Table 3 are statistics which will be useful in the profile analysis to be made later in this paper. It has been assumed that the sample of 120 curricula form a whole-set of data comprised of several differing subsets. Each subset presumably will have data means which *conform* or not to the data means of the whole-set. The range around the whole-set mean through which a subset mean can vary and still be assumed to conform to the whole-set is the "conformal limit." Conformal limits for the purposes here have been arbitrarily set so that 33 percent of the sample falls within the conformal limits of the adjusted means.

Figure 2 is a graphical representation of some of the data in Table 3. The abscissas on the figure give the adjusted mean of the semester credits required in various curricular areas of engineering technology programs. The bold line is a "profile" of such requirements; the shaded area represents the conformal limits of this profile. For convenience in plotting, a "bias" (axis calibration adjustment) has been made in three cases.

Curricular Differences
Related to Institutional Setting

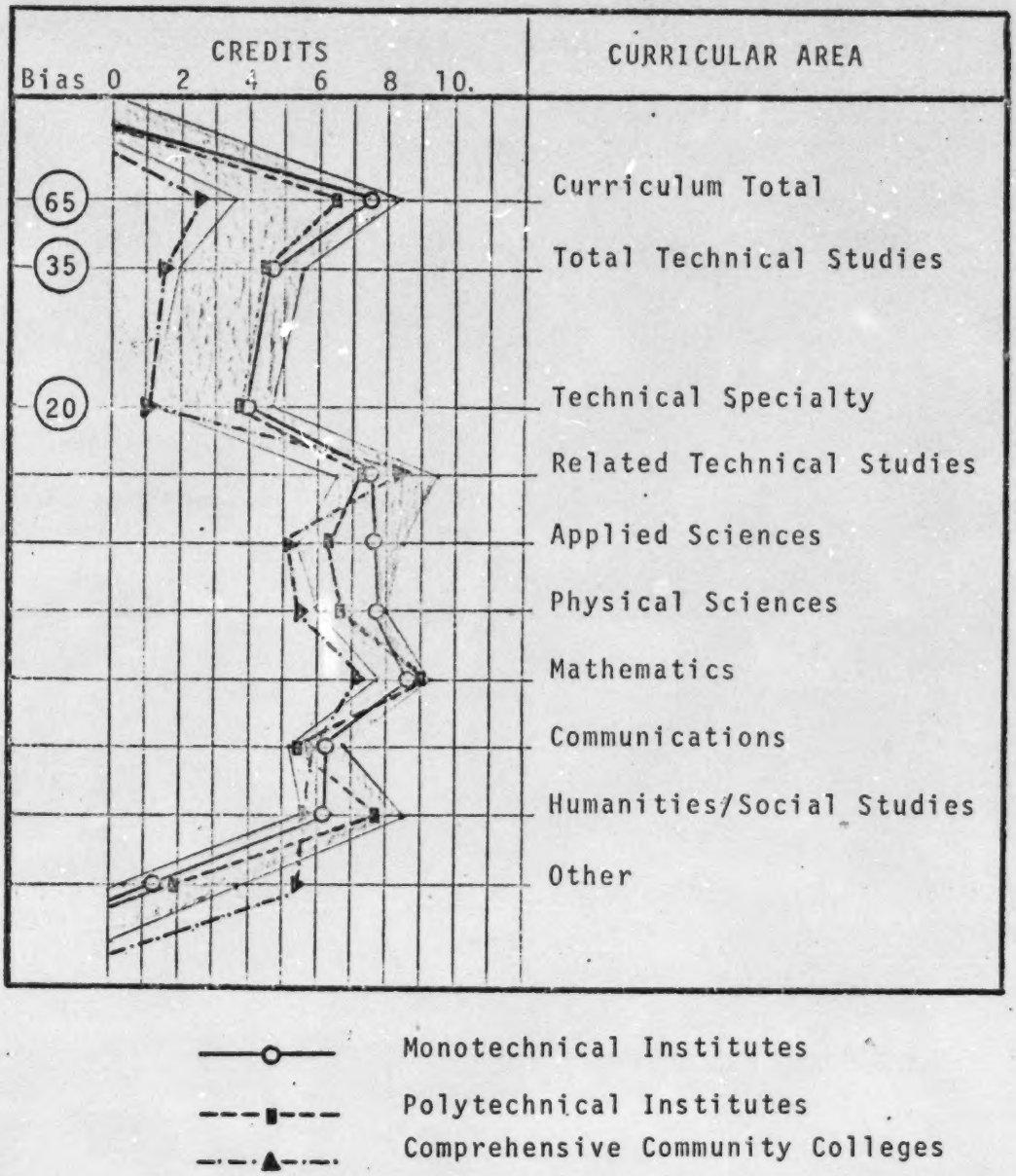
It was initially assumed that the curriculum structure of an engineering technology curriculum might vary with the institutional setting in which the curriculum is offered. To test this hypothesis, the profiles of three subsets of curricula--those existing in monotechnical institutes, polytechnical institutes, and comprehensive community colleges--were plotted and compared to the whole-set profile. The results are shown in Figure 3. Table 4 given the corresponding numerical data. The shaded area on Figure 3 represents the conformal limits of the whole-set profile (see Figure 2 and the accompanying discussion).

FIGURE 2.--Profile of the Curriculum Structure of a "Typical" Engineering Technology Program.



As can be readily seen from Figure 3, the profiles of the curricula which are offered in monotechnical institutes and in polytechnical institutes correspond closely and fall everywhere within the conformal limits of the whole-set profile. Programs in comprehensive community colleges, however, appear to have a curriculum structure with a noticeably different profile. The differences are discussed in the following:

FIGURE 3.--Profiles of Curriculum Structure of Engineering Technology Programs in Monotechnical Institutes, Polytechnical Institutes and Comprehensive Community Colleges



1. Community College curricula are shorter. This is not unexpected. Community colleges feel somewhat constrained to maintain equivalency in the length of all programs they offer; thus, the traditional length of the transfer (liberal arts) curriculum, 60-64 semester hours,

provides a boundary condition for the total length of curricula in technical fields.

2. Community college curricula have lower requirements for total technical studies. This is an obvious corollary of the previous finding. What is surprizing, however, is that the distribution of "total technical studies" in community colleges is irregular with respect to the whole-set profile rather than being uniformly lower. For example, the amount of technical specialty Subject matter required, although less than the mean, is within the conformal limits of the whole-set, but related technical studies appear to a greater extent than the mean and applied sciences are below the conformal limits.

3. Physical science and mathematics appear as requirements in community-college-based engineering technology curricula to a lesser extent than these subjects do in curricula from other institutional settings.

4. An appreciably greater number of credits in the engineering technology curricula having a community college setting are in the "other" category, that is, are comprised of physical education, R.O.T.C., foreign language, and "free" electives.

TABLE 4.--Mean Requirements by Curricular Area of Engineering Technology Programs Offered in Various Institutional Settings

Curricular Area	Monotechnical Institutes	Polytechnical Institutes	Comprehensive Comm. Colgs
Technical Specialties	24.0	23.9	21.2
Related Technical Studies	7.5	7.4	8.3
Applied Sciences	7.7	6.2	5.5
Physical Sciences	7.7	6.8	5.6
Mathematics	8.8	9.0	7.2
Communications	6.3	5.6	6.0
Humanities/Social Studies	6.4	7.7	5.8
Other	1.4	1.6	5.6
Total Technical Studies	39.9	39.7	36.7
Curriculum Total	72.8	71.8	67.7

The differences just noted are individually minor, but considered collectively lead to the inferences that community college curricula in engineering technology tend to be (1) less broadly based, since they tend to have fewer credits in the applied and physical sciences areas, and (2) less abstract, since they tend to have a somewhat more limited mathematics content. And because their subset profile differs from that of the sample as a whole, it is also possible to infer that the curriculum structure of community college engineering technology programs may be based on an educational philosophy different from that which motivates monotechnical and polytechnical institutes. *Such a generalization, however, is tenuous and must be used with extreme caution.*

Curricular Differences Related to Cognitive Domain

Engineering technology curricula were expected to show some differences related to the cognitive domains of the programs. For example, it was assumed that the typical curriculum structure of an electrical technology program might differ from that of a civil technology program. To test this hypothesis, the curriculum structure profiles of three subsets of curricula--*mechanical, civil, and electrical*--were plotted and compared. These were curricula all in the same kind of institutional setting; namely, polytechnical institutes. Figure 4 shows the results. As can be observed from the figure, programs in different cognitive domains sometimes differ appreciably in the way in which requirements are distributed, especially in the technical areas of the curricula.

Because the curriculum structures of programs in different cognitive domains do deviate from each other, an effort was made to assess this relative variance as compared to the variance in the structures of programs in different institutional settings. Hence, an analysis was made of the average difference in means for each set of

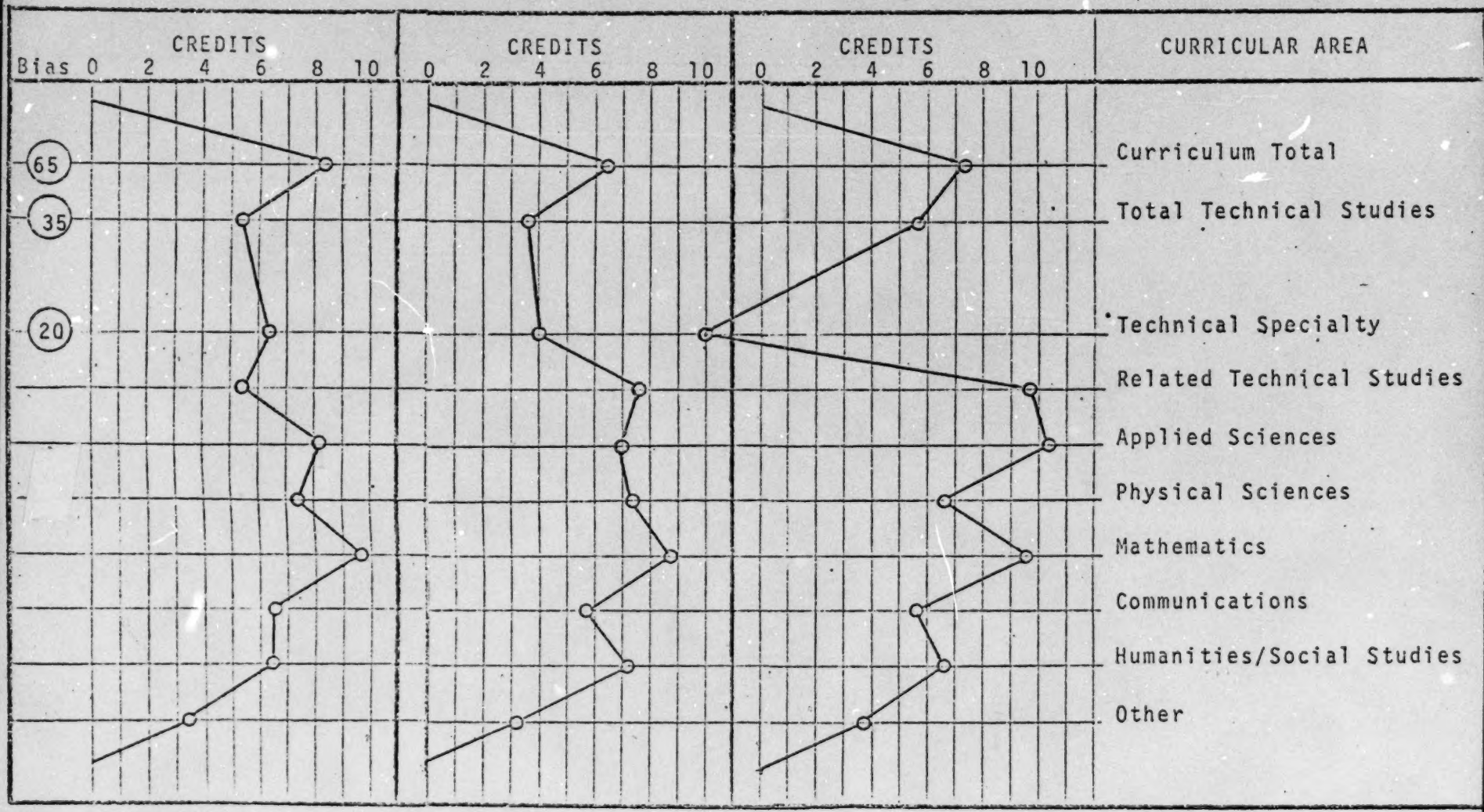


FIGURE 4.--Structural Profiles for three Kinds of Engineering Technology Programs, Illustrating Inter-program Structural Variance by Cognitive Domain.

profiles. The set of means for the entire sample (the whole-set) was used as a reference. Absolute values of the differences between whole-set means and corresponding subset means were calculated point-by-point. Then, the averages of these point-by-point differences were calculated. The average difference of means was 0.81 semester credits for programs in different institutional settings and 1.15 semester credits for programs in different cognitive domains. Thus, for the programs in this sample, the profile variance attributable to the "major" or "specialty" of engineering technology curricula is approximately 45 percent higher than that attributable to institutional setting. *The structural variation between curricula appears to be more dependent on the kind of technology with which it deals than on the kind of institution offering it.* This may be an important finding.

Curricula Differences
Related to Accreditation Status

An investigation was made of the differences which may exist between engineering technology programs accredited by the Engineers' Council for Professional Development and programs not so accredited. Two subsets of 25 members each were randomly selected from the total sample; one such subset consisted of accredited programs, the other, of nonaccredited programs. To test a hypothesis that differences exist, the structural profiles of accredited and non-accredited curricula were plotted. Figure 5 displays the results. The shaded area on the figure represents the conformal limits of the sample.[1] With one minor exception (total technical studies

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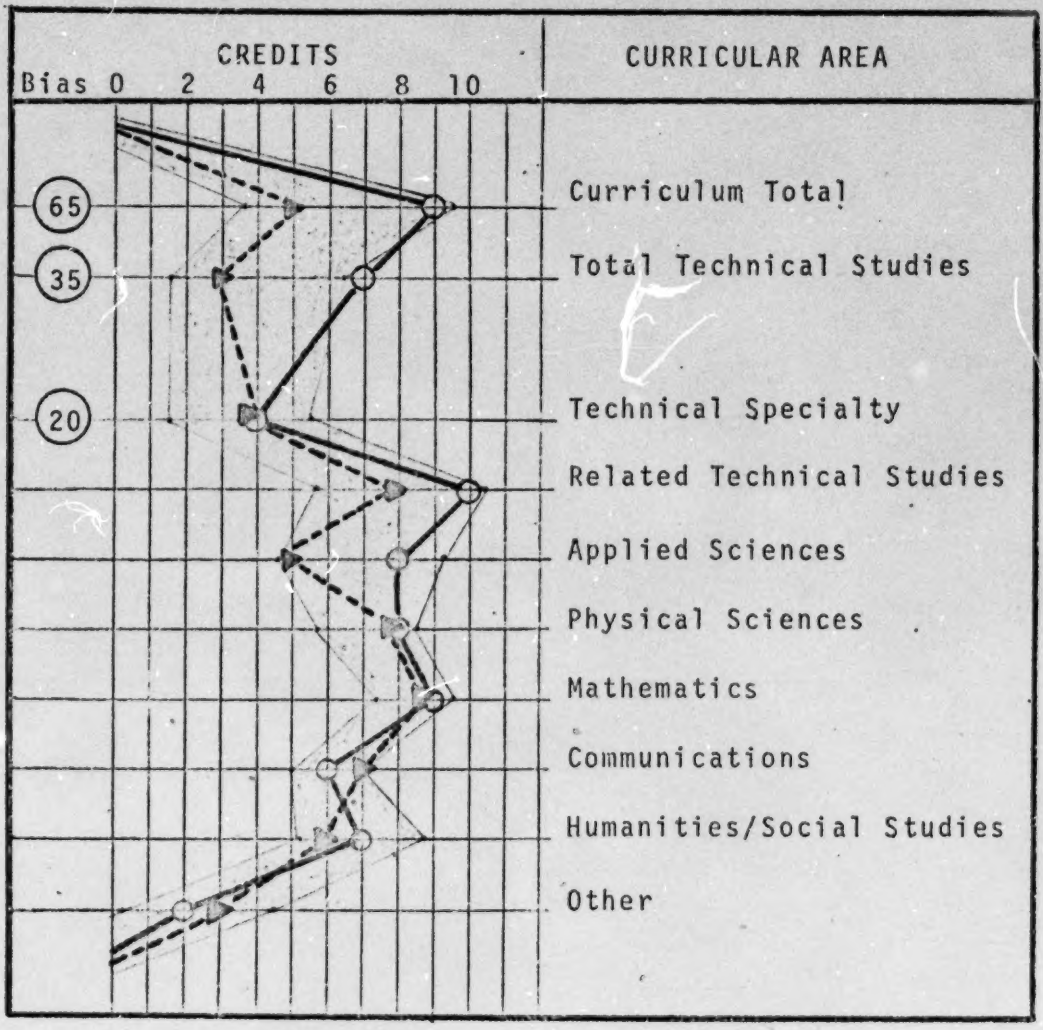
[1]The conformal limits for this figure are greater, by a factor of 1.4, than those employed for the previous analyses (Figures 2 and 3). Use of subsamples for this particular analysis introduces statistical sampling errors which increase the probable error in the computed means and hence increases the range through which one must assume "conformity" of the profiles.

FIGURE 5.--Structural Profiles of ECPD-Accredited and Non-accredited Engineering Technology Curricula



for accredited curricula), both profiles fall within the conformal limits of the whole sample's structural pattern. The hypothesis of difference is not sustained; the inference is that the accreditation status of a curriculum and its structural profile are not significantly related.

Modal Practices and Inter-program Consistencies

As was pointed out earlier in this paper, some of the data related to curriculum structure in engineering technology programs have variability characteristics which tend to limit the value of the mean for interpretations of the central tendencies of the data. The mode in many cases is possibly a more useful statistic, especially in describing usual practice. For example, the "Humanities/Social Studies" component of curriculum structure (see Table 2) has associated with it a mean requirement of 7 semester credits; hardly any single program contains such a requirement. Close examination reveals that the mode is 6 semester credits. In this case, actually three modes exist, one at 3 credits, another at 6 credits, a third at 8 credits; these presumably represent the practice of requiring either one 3-credit subject, two 3-credit subjects, or two 4-credit subjects in this area.

A profile of curriculum structure has been plotted to represent modal practice; this profile appears in Figure 6. In the figure modes have been used as data points rather than the adjusted means which were employed for the previous plots. The general similarity of Figure 6 to Figure 2 (which was based on means) is noteworthy; Figure 6 has an advantage of easy interpretation in terms of the credit units conventionally assigned to college courses. Examination of individual curricula reveals that many engineering technology programs have structural profiles which trace major sections of the modal profile.

One possible explanation for inter-program consistency can be offered. ASEE's *Characteristics of Excellence* (the "McGraw Report") had, in 1962, suggested certain guidelines for the structure of engineering technology curricula.[1] On

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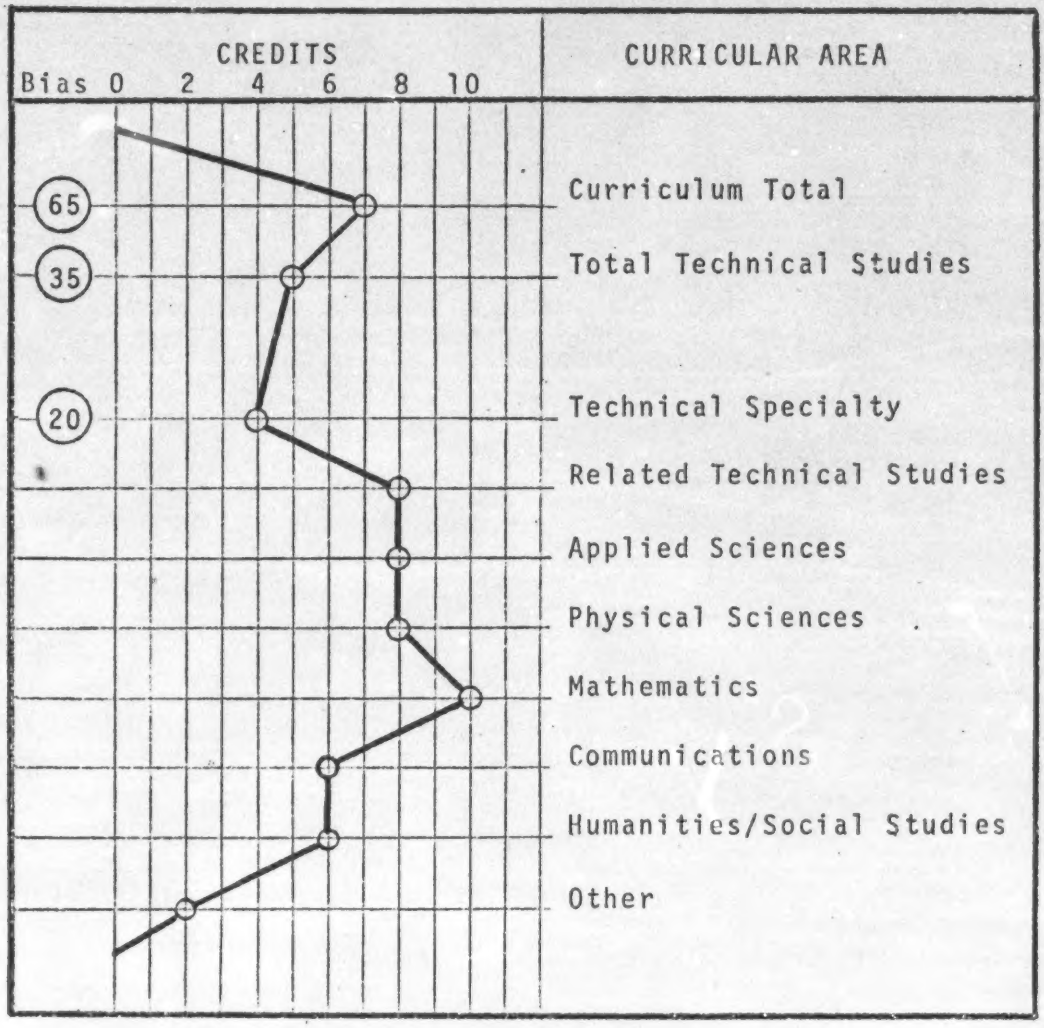
[1]American Society for Engineering Education, *Characteristics of Excellence in Engineering Technology Education*, The Society, Washington, D.C.: 1962.

FIGURE 6.--Modal Curriculum Structure Profile for Engineering Technology Curricula



Page 25 of this document, for example, an illustrative curriculum was presented, showing a recommended distribution of credits in certain curricular areas. That distribution is indicated in Table 5. Table 5 also gives for comparison purposes corresponding data for the curricular areas of the modal engineering technology program discussed above. (Editorial revisions have been made both in the terminology used in the McGraw Report and that previously used here in order to facilitate comparison; the McGraw

TABLE 5.--Distribution of Credits in McGraw's "illustration" and in the Modal Engineering Technology Program

Curricular Area	Semester Credits	
	Suggested by McGraw, 1962	Modal Program, 1970
Total Technical Studies	39	40
Physical Sciences	6	8
Mathematics	12	10
Communications	6	6
Humanties/Social Studies	6	6
Other	3	2
Curriculum Total	72	72

Report did not treat as many curricular subdivisions as were used here. See Appendix C for the exact terminology originally used.) Examination reveals a high degree of correspondence between items in the table. Two inferences are possible: (1) that the 1962 McGraw Report has had a tremendous directive influence on the evolution of engineering technology education programs; and/or (2) that the general structure of engineering technology education programs has not appreciably changed since the McGraw Report was issued.

Summary

Engineering Technology education programs are available in seven kinds of institutional settings:

1. monotechnical institutes
2. polytechnical institutes
3. comprehensive community colleges
4. universities
5. company schools
6. service schools
7. correspondence schools

The first four classifications account for the majority of the programs.

For various reasons, it is difficult to inventory the national effort in engineering technology education. Perhaps the best estimate of the population is that approximately 560 institutions offer nearly 1600 curricula.

Curriculum structure in engineering technology education programs vary somewhat with institutional setting and with the cognitive domain of the programs. Analysis of the distribution of the number of semester credits required in various curricular areas leads to the following estimates of "typical" structural profiles:

Curricular Area	Mean Requirement
Technical Specialty	23
Related Technical Studies	8
Applied Sciences	7
Physical Sciences	7
Mathematics	8.5
Communications	6
Humanities/Social Studies	7
Other	2
Total Technical Studies	39
Curriculum Total	71

Profile analysis yeilds the following:

1. Monotechnical and polytechnical institutes offer programs with essentially identical structures.

2. Community colleges offer programs which are shorter in total length, contain fewer credits in physical science and mathematics, and have more "free" electives.

3. University-based programs are like those in monotechnical and polytechnical institutes.

4. Curriculum structure varies more with program emphasis (cognitive domain) then with institutional setting.

5. Programs which are accredited by ECPD do not differ significantly in their curriculum structure from programs not ECPD accredited.

A comparison of the "modal" profile of existing engineering technology curricula (the mode being for this purpose a more useful descriptive statistic than the mean) with the illustrative curriculum in the McGraw Report reveals close correspondence between these two.

Implications.

The possible implications of the analysis described in this paper must be extrapolated, for they are not entirely explicit in the data. The implications fall into two major domains.

First, it can be readily noted that the majority of engineering technology curricula have semester hour requirements--regardless of the institutional setting--which exceed those normally associated with two years of college work. The range of requirements of the associate degree in engineering technology was found to be from 60 to 83 semester credits, with a mean of 71 and a mode of 72. To many observers, such data indicates a serious "overcrowding" of the curriculum, especially when the mean abilities of entering students (see ETE Study Report No. 5) are considered. There may also be implications that only certain kinds of institutional settings are appropriate for engineering technology programs.

And secondly, the lack of variability among programs--in most of the curricular areas treated and with respect to several different variables--suggests that a "lock-step" configuration may exist in this educational domain. While inter-program conformity may well help assure that certain minimum standards are being widely met, a high degree of such conformity may indicate that little educational experimentation or innovation is occuring in the area. The characteristics of engineering technology curricula are well defined; all programs in this area have structural patterns which are surprizingly similar and the differences which do exist among programs are minor. But such conformity in itself gives rise to a dilemma with which educators and others sensitive to the needs in the area must wrestle.

APPENDIX A

Discussion of Sample

Appendix A

THE SAMPLE USED IN THE ANALYSIS OF ENGINEERING TECHNOLOGY CURRICULA

The sample consisted of 120 curricula at 21 different institutions. Nineteen of these institutions were personally visited by the author. In the sample, 71 curricula were accredited by ECPD.

The distribution by discipline of the curricula in the sample is indicated in Table A-1.

The classification of curricula in the sample by institutional setting is given in Table A-2. The original intent had been to provide for approximately 30 members of each category, an objective satisfactorily achieved. However, preliminary study showed that university programs--because

TABLE A-1.--Titles of Curricula in Sample

Approximate Curriculum Title	Number
Aeronautical	4
Air Conditioning	3
Architectural (including building construction)	13
Chemical	8
Civil (including surveying, highways)	18
Drafting/Design	8
Electrical	7
Electronics	21
Industrial (including manufacturing)	7
Mechanical	18
Metallurgical (including Materials)	4
Other (automotive, computer, petroleum, fire protection, nuclear)	9
TOTAL	120

TABLE A-2.--Institutional Settings of Curricula in Sample

Kind of Institution	Number of Curricula
Monotechnical Institutes	24
Polytechnical Institutes	35
Comprehensive Community Colleges	28
Universities	33
TOTAL	120

TABLE A-3.--Groupings of Curricula Used in Analysis

Kind of Institution	Number of Curricula
Monotechnical Institutes	54
Polytechnical Institutes	38
Comprehensive Community Colleges	28
TOTAL	120

of their assignment to separate branches, campuses, departments or other instructional units--resembled closely the programs in either monotechnical institutes or polytechnical institutes. A reassignment of the 33 curricula in universities resulted in the distribution shown in Table A-3; this grouping was used through the analyses conducted. Although the cells are unbalanced as a result of the regrouping, the internal variance in each cell is virtually unaffected.

The sample was taken approximately equally from the various geographic regions of the United States. Table A-4 shows the geographic distribution of the sample. While the

northeastern region is somewhat over-represented in the sample, this region also possesses a disproportionately high fraction of the total institutional population which is engaged in engineering technology education. The distribution is deemed satisfactory for these purposes.

TABLE A-4.--Geographic Distribution of Institutions and Curricula Included in Sample

Geographic Region	Number of Institutions	Number of Curricula
Northeast	5	34
Southeast	4	18
North Central	4	30
South Central	4	20
West	4	18

APPENDIX B

Techniques for Curriculum Analysis

Appendix B

TECHNIQUES FOR CURRICULUM ANALYSIS

The quantitative analysis of an engineering technology curriculum involves steps of classification and distribution. Study of the curriculum guide as published in the *Bulletin* or *Catalog* of an institutions and careful reading of descriptions of the various courses the titles of which appear in the curriculum guide usually yield sufficient information for these processes.

Each subject listed in the curriculum guide is classified as belonging to one of the following curricular areas:

Technical Specialty
Related Technical Studies
Applied Sciences
Physical Sciences
Mathematics
Communications
Humanities/Social Studies
Other

Then, the credits listed for each subject are distributed to the appropriate curricular area on a curriculum analysis worksheet. Calculation of subtotals and totals by curricular area completes the analysis.

Certain arbitrary interpretations are often necessary. For example, a subject with a title of "surveying", which would be a technical specialty subject in a Civil Technology program, has been classified as related technical study for Building Construction Technology. Other similar interpretations, based on the purported objectives of individual programs and published course descriptions, must be made from time to time.

The process is illustrated on the exhibits following. Included in these exhibits are copies of catalog pages, curriculum guides and an analysis worksheet. The handwritten notes were made by the researcher during the analysis. Interested readers can follow the process.

CIVIL ENGINEERING TECHNOLOGY

Civil engineering technicians do level and transit work in surveying, make and check surveying and construction notes, test soil and materials, perform routine engineering design computations, make construction drawings, or supervise and inspect construction work.

Civil engineering technology provides a balance between outdoor and indoor work which many young men find desirable. Surveying, soil testing, construction supervision and inspection are essentially outdoor work, while drafting and design are indoor.

First Semester	*Credits*	*Second Semester*	*Credits*
English Comp. (40.101)	3	English Comp. (40.102)	3
Technical Algebra and Trigonometry (50.081)	5	Tech. Analytic Geom. and Calculus (50.082)	4
Physics (78.101)	4	Physics (78.102)	4
Chemistry (72.103)	4	Descriptive Geometry (30.110)	3 *
Engineering Drawing (30.100)	3	Mechanics (19.081)	(4)
Total	19	Total	~~18~~ 17

Third Semester	*Credits*	*Fourth Semester*	*Credits*
Tech. Analytic Geom. and Calculus (50.083)	3	Hydraulics (14.094)	2
Plane Surveying (14.095)	3	Construction Office Practices (14.097)	4
Strength of Materials (19.083)	(4) *	Structural Analysis (14.096)	4
Highway and Structural Drafting (14.091)	2	Industrial Organization and Management (20.080)	3
Human Relations (88.032)	3	Construction Materials (14.093)	3
American Civilization (82.100)	3	Highway and Structural Design (14.092)	2
Physical Education (90.101 or 90.111)	1	Physical Education (90.102 or 90.112)	1
Total	~~19~~ 18	Total	19

Worksheet, Showing Published Curriculum Guide and Classification of Subject

I

Comm. = 3
Math = 5
P. Sci. = 4
P. Sci. = 4
Rel. Tech = 3

II

Comm. = 3
Math = 4
P. Sci. = 4
Rel. Tech = 3
* Appl Sci = 3

III

Math = 3
T. Spec. = 3
* Appl Sci = 3
T. Spec = 2
H/SS = 3
H/SS = 3
Other = 1

IV

T. Spec = 2
T. Spec = 4
T. Spec = 4
Rel Tech = 3
T. Spec = 3
T. Spec = 2
Other = 1

* Described in catalog as 3 credits each

37

CATALOG DESCRIPTIONS

WORKSHEET

14.091 HIGHWAY AND STRUCTURAL DRAFTING 2 credits

Prerequisite: Engineering Drawing 30.100, Descriptive Geometry 30.110.
Three two-hour laboratory periods each week.

This course employs the basic principles of Engineering Drawing and Descriptive Geometry as applied to the highway and structural drafting problems. Emphasis is placed on developing professional working drawings from the survey and field notes.

SEM III
TECH. SPEC.
2 CREDIT
0-6

14.092 HIGHWAY AND STRUCTURAL DESIGN 2 credits

Prerequisite: Highway and Structural Drafting 14.091.
One lecture and one three-hour laboratory period each week.

This course is a continuation of Highway and Structural Drafting. Students will execute basic designs on bridge, culvert retaining walls and related structures. Field trips to construction sites are included as an integral part of the course.

SEM IV
TECH. SPEC.
2 CREDIT
1-3

14.093 CONSTRUCTION MATERIALS 3 credits

Prerequisite: Strength of Materials 19.083.
Three hours each week.

A study of the production, composition and properties of both metal and non-metal construction materials. Consideration is given to the suitability of the various materials to specific construction problems.

SEM. IV
TECH. SPEC.
3 CREDIT
3-0

14.094 HYDRAULICS 2 credits

Prerequisite: Mathematics 50.081.
Two hours each week.

The elementary study of fundamentals of hydrostatics with emphasis on flow through orifices, pipes, channels and weirs.

SEM. IV
TECH SPEC
2 CREDIT
2-0

14.095 PLANE SURVEYING 3 credits

Prerequisite: Mathematics 50.081.
One lecture and two three-hour laboratory periods each week.

The theory and practice of plane surveying, including the use and care of transit, level, compass and tape. Emphasis is placed on laboratory problems in measurements of areas, heights, and angles; calculations of traverses, topographic mapping and field methods.

SEM. III
TECH SPEC.
3 CREDIT
1-6

14.096 STRUCTURAL ANALYSIS 4 credits

Prerequisite: Strength of Materials 19.083.
Four hours each week.

This course is a continuation of the Strength of Materials course going into advanced work. Deflection of trusses and solution of indeterminate trusses by the method of internal elastic work is explained. The deflection of simple and continuous beams by the area movement method is discussed. Solutions for indeterminate beams are given. Many problems in beam, column and riveted tank design are assigned.

SEM. IV
TECH. SPEC.
3 CREDIT
4-0

14.097 CONSTRUCTION OFFICE PRACTICES 4 credits

Prerequisite: Drafting 14.091.
Three lectures and one three-hour laboratory period each week.

Principles of office practices in Civil Engineering construction. Emphasis is placed on construction methods and construction materials as they apply to specification writing and estimating, with some attention given to construction supervision.

SEM. IV
TECH. SPEC.
4 CREDIT
3-3

19.081 MECHANICS-STATICS 3 credits

Prerequisite: One unit of high school algebra and one unit of high school geometry or Mathematics 50.002.
Three lecture hours each week.

In addition to forming a theoretical foundation for future work in civil and mechanical engineering technology, this course constitutes an excellent introduction to mechanical or structural science. The course is essentially a study of forces and their effects on motionless objects. Applications to trusses, beams, frames, and other topics are presented.

SEM. II
APPL. SCI.
3 CREDIT
3-0

19.083 STRENGTH OF MATERIALS 3 credits

Prerequisite: Mechanics-Statics 19.081.
Two lecture and two laboratory hours each week.

This course consists of the study of the reaction of materials to tension, compression torsion and flexure. Applications to the design of beams, columns, shafts, and fasteners are presented. The students perform various materials tests in a fully equipped laboratory.

SEM. III
APPL. SCI.
3 CREDIT
2-2

20.080 INDUSTRIAL ORGANIZATION AND MANAGEMENT 3 credits

Prerequisite: None.
Three hours each week.

A survey of modern practices and techniques through which sound management principles of planning, organizing, directing, staffing and controlling may be applied effectively to the manufacturing activities of an industrial enterprise.

SEM. IV
REL. TECH. STUDIES
3 CREDIT
3-0

30.100 ENGINEERING DRAWING 3 credits

Prerequisite: None.
Six one-hour laboratory periods each week.

This course introduces the elementary techniques of drafting including: use of instruments, lettering, geometric construction, principles of orthographic projection, pictorial drawing, technical sketching, sectional views and conventions, threads and fasteners, dimensioning, detail and assembly drawings. For engineering and industrial technicians.

SEM. I
REL. TECH. STUDIES
3 CREDIT
0-6

CATALOG DESCRIPTIONS

WORKSHEET

30.110 DESCRIPTIVE GEOMETRY 3 credits

Prerequisite: Engineering Drawing 30.100.
Six One-hour laboratory periods each week.

The structure of this course emphasizes the fundamental theories of space relationships of points, lines, planes, intersections of surfaces and developed surfaces with applications to practical problems. Reinforcement of skills and principles introduced in Engineering Drawing 30.100 is an important objective of the course. Problems include clearances and angular relationships between structures, machine parts, etc.

SEM. II
REL. TECH. STUDIES
3 CREDIT
0-6

40.101 ENGLISH COMPOSITION I 3 credits

Prerequisite: Satisfactory score on placement test.
Three hours each week.

A review of the principles of composition including rhetoric, grammar and usage with emphasis on the writing of analytical essays and a study of the principles underlying critical thinking.

SEM. I
COMMUNICATIONS
3 CREDIT
3-0

40.102 ENGLISH COMPOSITION II 3 credits

Prerequisite: English 40.101.
Three hours each week.

Practice in writing longer units of exposition: simple argumentation; the critical paper. Emphasis on style, imagery, tone. Research techniques taught.

SEM. II
COMMUNICATIONS
3 CREDITS
3-0

50.081 TECHNICAL ALGEBRA AND TRIGONOMETRY 5 credits

Prerequisite: One unit of high school algebra and one unit of high school geometry or Mathematics 50.030 with a grade of C or better.
Five hours each week.

This course will cover in one semester all the topics of algebra and trigonometry needed for Mathematics 50.082. Particular emphasis will be placed on applications for career students.

SEM. I
MATH.
5 CREDIT
5-0

50.082 TECHNICAL ANALYTICAL GEOMETRY AND CALCULUS I 4 credits

Prerequisite: Mathematics 50.081 or equivalent.
Four hours each week.

Course content includes rectangular coordinate system, slope. Equation of a straight line. Conic sections. Circle, ellipse, hyperbola, parabola. The derivative. Differentiation of algebraic forms. Implicit derivatives. Derivatives of higher order. Curve sketching. Extreme values. Applications of the derivative involving maxima and minima. Differentials. Derivatives of trigonometric functions and inverse trigonometric functions. Derivatives of logarithmic and exponential functions.

SEM II
MATH.
4 CREDIT
4-0

CATALOG DESCRIPTIONS

WORKSHEET

50.083 TECHNICAL ANALYTICAL GEOMETRY AND CALCULUS II — 3 credits

Prerequisite: Mathematics 50.082
Three hours each week.

Course content includes the antiderivative. Integration of trigonometric and exponential forms. Definite integral and its interpretation as area. Applications of the integral; volumes of solids of revolution; surface area of solids of revolution. Centroid of an area. Moment of inertia. Work. Integration techniques. Polar equations. Area and arc length in polar coordinates. Parametric equations. Derivatives in parametric equations.

SEM. III
MATH
3 CREDIT
3-0

72.051 TECHNICAL CHEMISTRY — 4 credits

Prerequisite: None.
Three lectures and one three-hour laboratory period each week.

A study of the general principles of chemistry with particular attention to industrial applications.

SEM. I
PHYS. SCI.
4 CREDIT
3-3

78.101 COLLEGE PHYSICS I — 4 credits

Prerequisite: Concurrent with or preceded by Mathematics 50.105.
Three lectures and one two-hour laboratory period each week.

A study of mechanics, properties of matter, heat and sound. Lectures, demonstrations and problems.

SEM. I.
PHYS. SCI.
4 CREDIT
3-2

78.102 COLLEGE PHYSICS II — 4 credits

Prerequisite: Physics 78.101 or Engineering 19.081 and 19.083.
Three lectures and one two-hour laboratory period each week.

A study of light, magnetism, electricity and atomic and nuclear physics. Lectures, demonstrations and problems.

SEM. II
PHYS. SCI.
4 CREDIT
3-2

82.100 AMERICAN CIVILIZATION — 3 credits

Prerequisite: None.
Three hours each week.

A study of American history, institutions and government. Special consideration will be given to the Constitutions of the United States and Missouri and special historical emphasis will be placed on the twentieth century. Intended primarily for students in career curricula.

(Credit not allowed for this course if credit is given for History 82.101 or 82.102.)

SEM. III
H/SS
3 CREDIT
3-0

88.032 HUMAN RELATIONS — 3 credits

Prerequisite: None.
Three hours each week.

This course is designed as an introduction to the basic principles of sociology, general psychology, and industrial psychology. Major emphasis is placed on such topics as the origin and development of the social body, group behavior, and the problems attendant to leadership and cooperation. Designed to develop a thorough understanding of good human relationships in the industrial complex. The course also proposes to aid in the formation of sound citizenship.

SEM. III
H/SS
3 CREDIT
3-0

CATALOG DESCRIPTIONS

WORKSHEET

90.101 PHYSICAL EDUCATION FOR MEN 1 credit

Prerequisite: None.
Two hours each week.

Introduction to Physical Education activities. Emphasis on physical fitness and physical conditioning. Includes fitness exercises and tests; fundamentals of stunts, tumbling, and apparatus work; cageball; self-testing exercises.

SEM III & SEM IV
OTHER
1 CREDIT EACH
0-2

90.102 PHYSICAL EDUCATION FOR MEN 1 credit

Prerequisite: None.
Two hours each week.

Team sports. Instruction and practice in techniques of basketball, volleyball, and hoc-soc. Other team sports as appropriate.

90.111 PHYSICAL EDUCATION FOR WOMEN 1 credit

Prerequisite: None.
Two hours each week.

Introduction to Physical Education activities. Includes body mechanics; exercises for body condition and figure control; stunts, tumbling, and apparatus work; square dancing and folk dancing.

90.112 PHYSICAL EDUCATION FOR WOMEN 1 credit

Prerequisite: None.
Two hours each week.

Team sports. Fundamentals and practices in techniques of basketball, volleyball, and speed-ball.

WORK SHEET FOR ANALYSIS OF CURRICULUM

Institution _____ Code 102

Curriculum Title CIVIL ENGINEERING TECHNOLOGY Type COMM. COLG.

Terminal Award AAS Calendar SEMESTER Enrollment _____

Curricular Area	Year 1		Year 2		Year 3		Year 4		Total	Detail Class	Detail Lab.
Technical Specialty Studies			5	15					20	14	6 (18)
Related Technical Studies	3	3		3					9	3	6 (12)
Engineering Science		3	3						6	5	1 (2)
Physical Science	8	4							12	9	3 (7)
Mathematics	5	4	3						12	12	0 (0)
Communications	3	3							6	6	0 (0)
Humanities/Social Studies			6						6	6	0 (0)
Other Studies			1	1					2	0	2 (4)
Total Technical									35		
TOTAL	19	17	18	19					73	55	18 (43)

REMARKS:

1. IN "LAB" COLUMN, NUMBERS IN PARENTHESES REPRESENT CONTACT HOURS
2. NOT ACCREDITED BY ECPD.
3. "OTHER" = PHYSICAL EDUCATION.

APPENDIX C

Excerpt from McGraw Report

Appendix C

EXCERPT FROM McGRAW REPORT

This table appeared on page 25 of the 1962 "McGraw Report" (*Characteristics of Excellence in Engineering Technology Education,* American Society for Engineering Education, 1962) and indicates the curricular areas used in that study for analysis of program structure.

CURRICULUM SUMMARY IN SEMESTER CREDITS

	*Minimum		Illustration	
Basic Science Courses				
Mathematics (e.g. algebra, trigonometry, calculus)	9		12	
Physical Sciences (e.g. physics, chemistry)	6	15	6	18
Non-Technical Courses				
Communications (e.g. English composition, speech, report writing)	6		6	
Humanistic-Social Studies (e.g. economics, literature, history)	6		6	
Other (e.g. management, human relations, or additional humanistic-social studies)	3	15	3	15
Technical Courses				
Technical Skills (e.g. drafting-basic, manufacturing processes)	6		6	
Technical Specialties (e.g. semiconductors, strength of materials)	24	30	33	39
Totals		60		72

*Institutions should view with concern any curriculum which meets only the minimum shown above. Variations above the minimum are not only expected but desirable.